

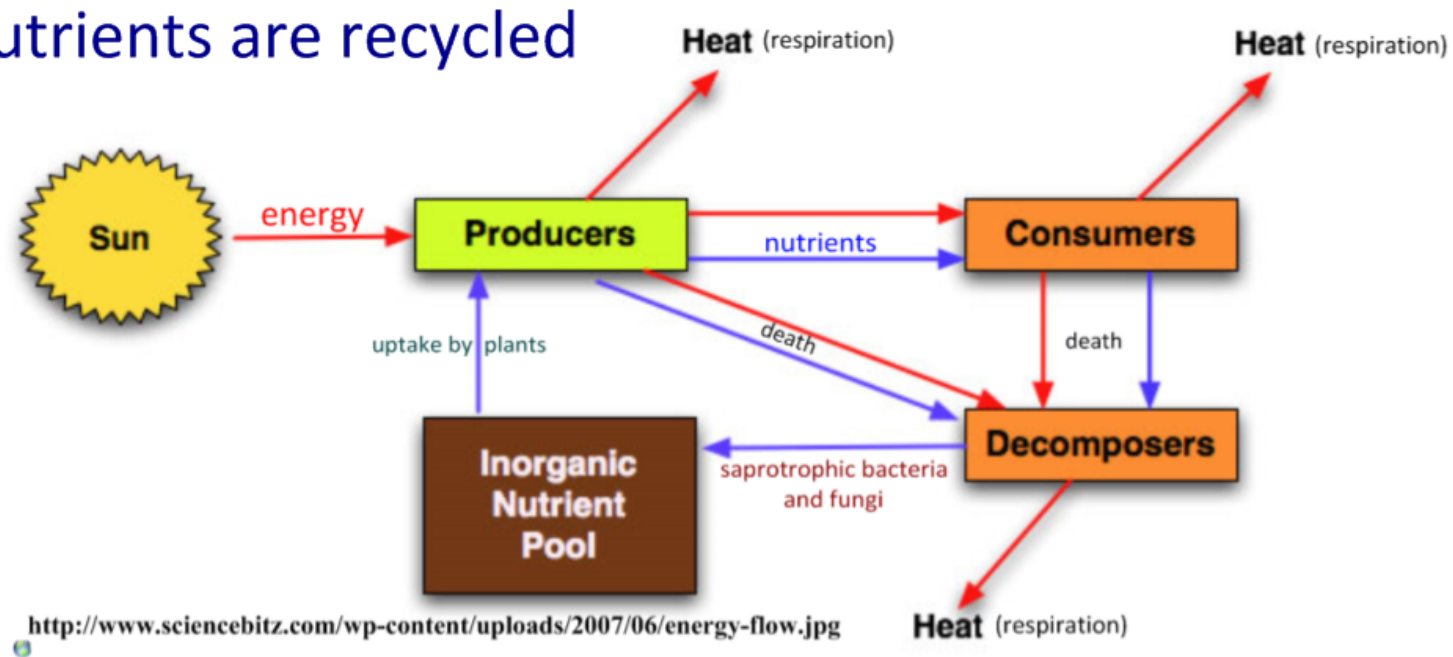
Ecosystems and Biomes

Stephen Taylor

Bandung International School

Energy flows, nutrients are recycled

(From 5.1)



Energy:

- energy enters from sunlight
- autotrophs capture sunlight
- energy flows through the trophic levels / stages in food chain
- energy transfer is (approximately) 10 % from one level to the next
- energy loss due to material **not consumed** **assimilated** / **egested** / **excreted**
- energy passes to decomposers / detritivores / saprotrophs in dead organic matter
- heat energy is lost through cell respiration

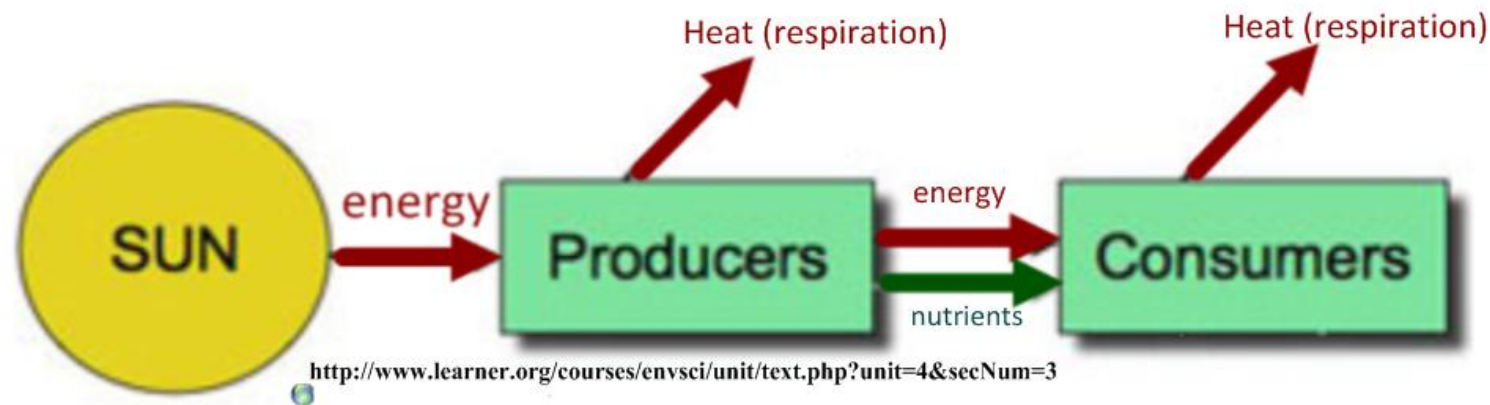
Nutrients:

- nutrient cycles within ecosystem / nutrients are recycled
- nutrients from weathering of rocks enter ecosystem
- nutrients recycled from **decomposition of dead organisms**
- nutrients move through (food chain) by **digestion of other organisms**
- nutrients absorbed by producers / plants / roots
- nutrients lost by leaching / sedimentation (e.g. shells sinking to sea bed)

Energy flows through the ecosystem

Why is so little energy passed along to each trophic level?

$$NP = GP - R$$



$$NP = GP - R$$

Net production:

*the amount of **organic matter** remaining after **respiration***

Gross production:

*the total amount of **organic matter** produced in an ecosystem*

Respiration:

Stored energy used in the cellular production of ATP

Organic matter: _____ becomes **Biomass**

starch (stored energy)

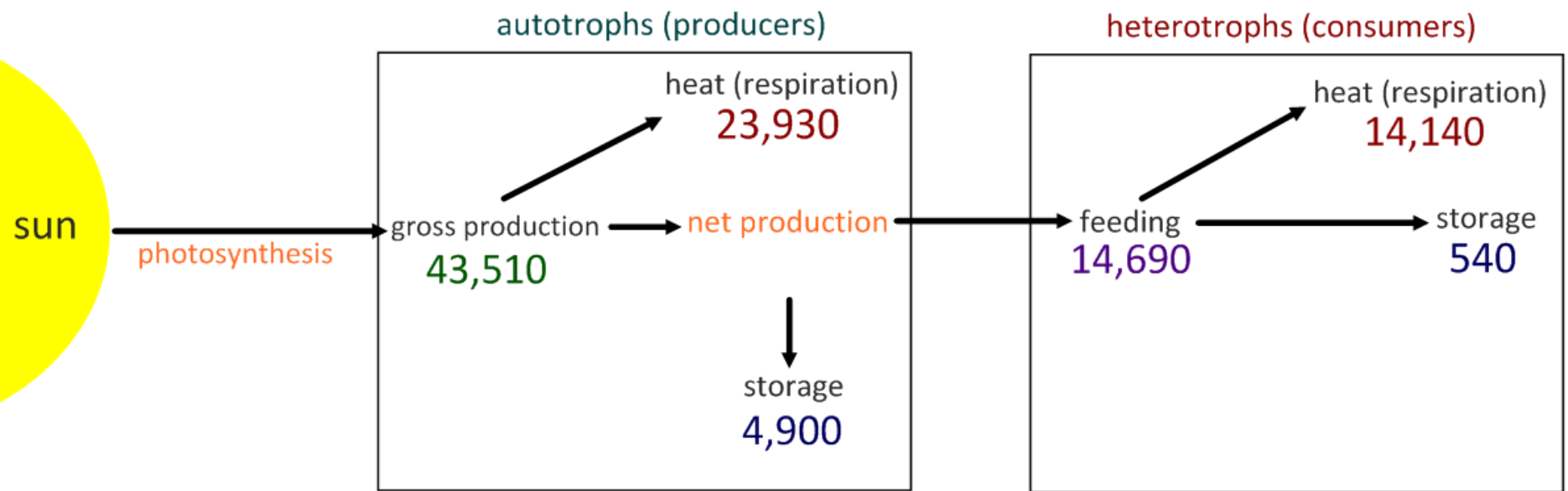
proteins & structural molecules

A lot of stored energy and

nutrients are used by each individual.

*the **total dry mass** of **organic matter** in organisms or ecosystems.*

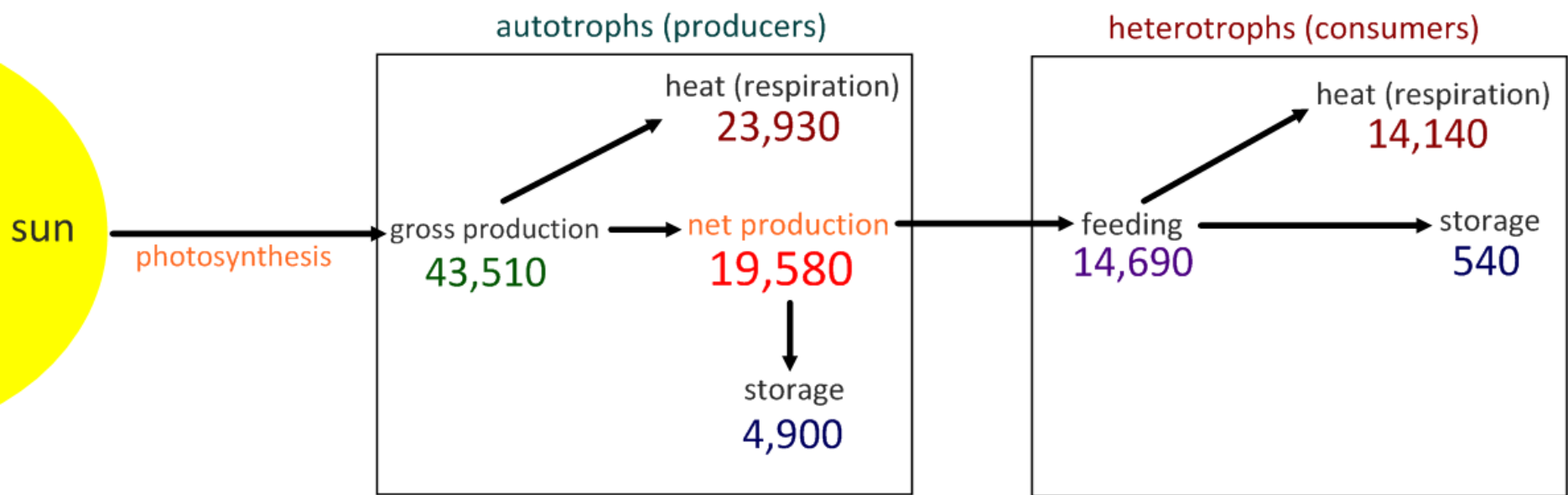
The unit of energy used is $\text{kJ m}^{-2} \text{y}^{-1}$ (energy per square metre per year)



$$NP = GP - R$$

1. Calculate the net production of the autotrophs

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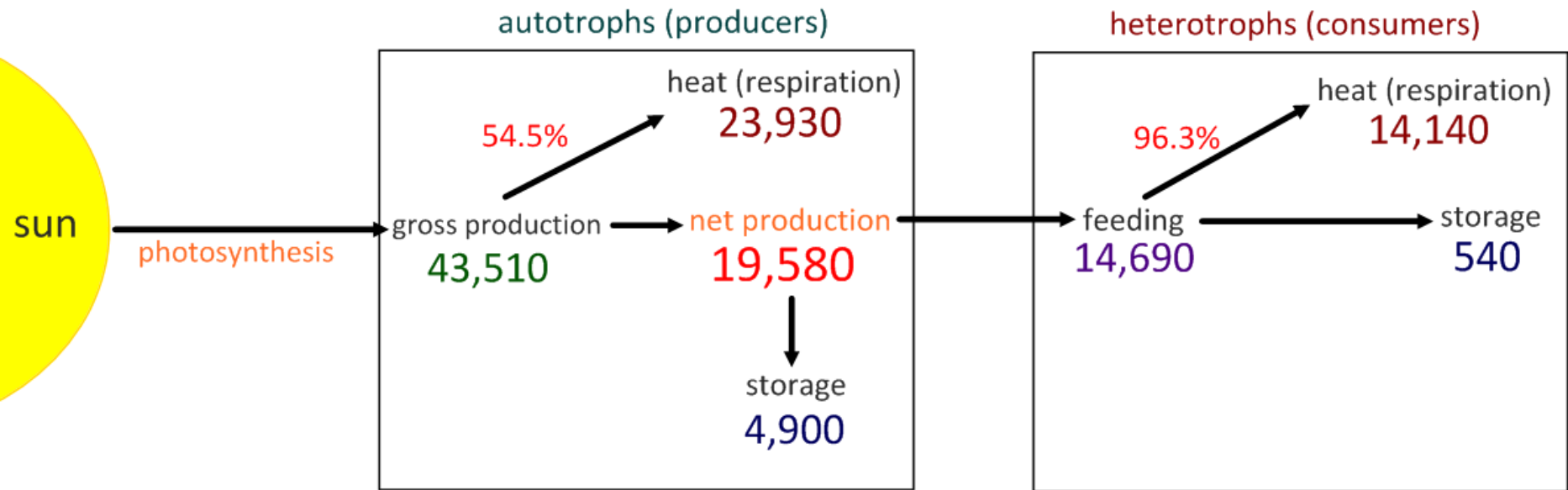
$$= 43,510 - 23,930$$

$$= 19,580 \text{ kJ m}^{-2} \text{y}^{-1}$$

(don't forget the units)

2. Compare the percentage of energy lost in respiration between autotrophs and heterotrophs. Can you suggest why?

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2. Compare the percentage of energy lost in respiration between autotrophs and heterotrophs.
Can you suggest why?

autotrophs (producers)

$$\frac{23,930}{43,510} \times 100 = \underline{54.5\%}$$

heterotrophs (consumers)

$$\frac{14,140}{14,690} \times 100 = \underline{96.3\%}$$

Heterotrophs consume much more energy for respiration than autotrophs:

- maintaining body temperature
- movement
- energy expended in reproduction

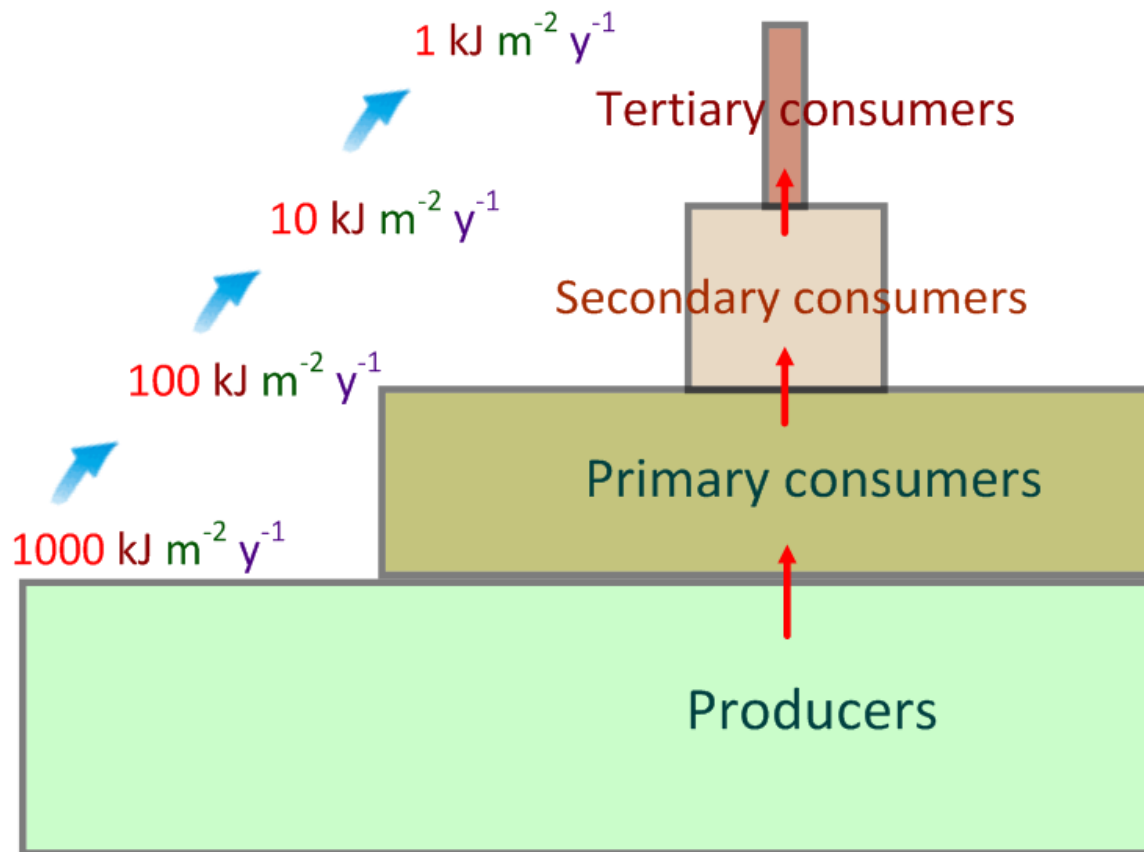
Pyramids of energy

(From 5.1)

show the **flow of energy** between **trophic levels**

Measured in **units of energy per unit area per unit time**: $\text{kJ m}^{-2} \text{y}^{-1}$

Transfer of energy is **never 100% efficient**.



Around **90% of energy** is **lost** **between trophic levels**:

- not ingested (eaten)
- not digested or assimilated
- excreted
- lost as heat from respiration

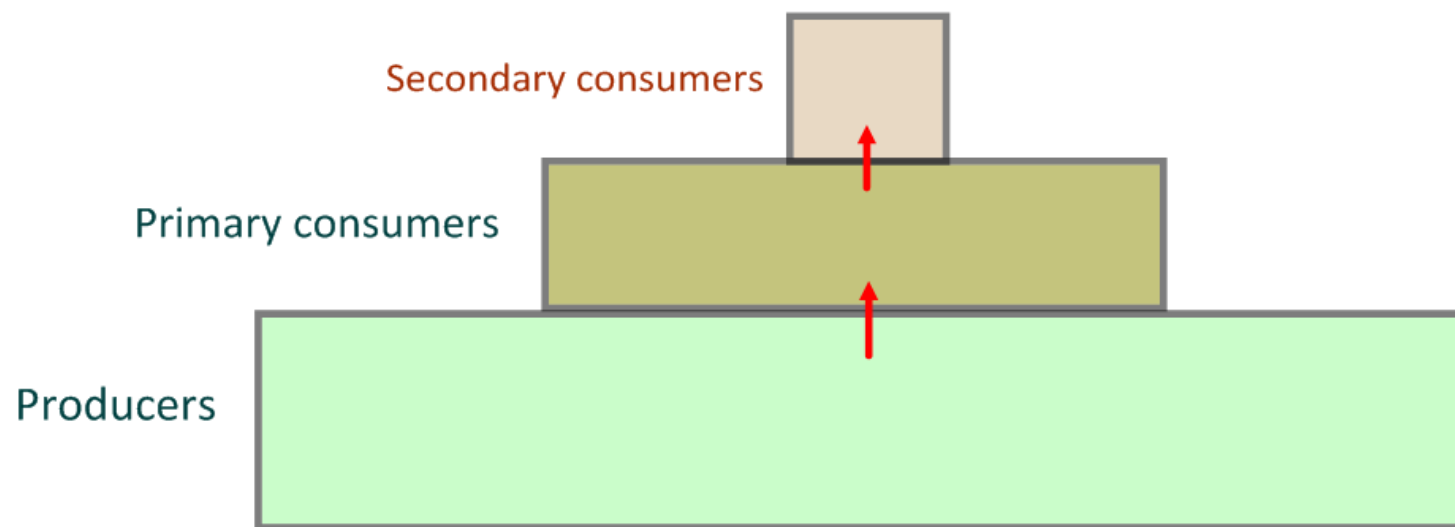
Produce a **pyramid of energy** using this information:

The total solar energy received by a grassland is $5 \times 10^5 \text{ kJ m}^{-2} \text{ y}^{-1}$.

The net production of the grassland is $5 \times 10^2 \text{ kJ m}^{-2} \text{ y}^{-1}$ and its gross production is $6 \times 10^2 \text{ kJ m}^{-2} \text{ y}^{-1}$.

The total energy passed on to primary consumers is $60 \text{ kJ m}^{-2} \text{ y}^{-1}$.

Only 10 % of this energy is passed on to the secondary consumers.



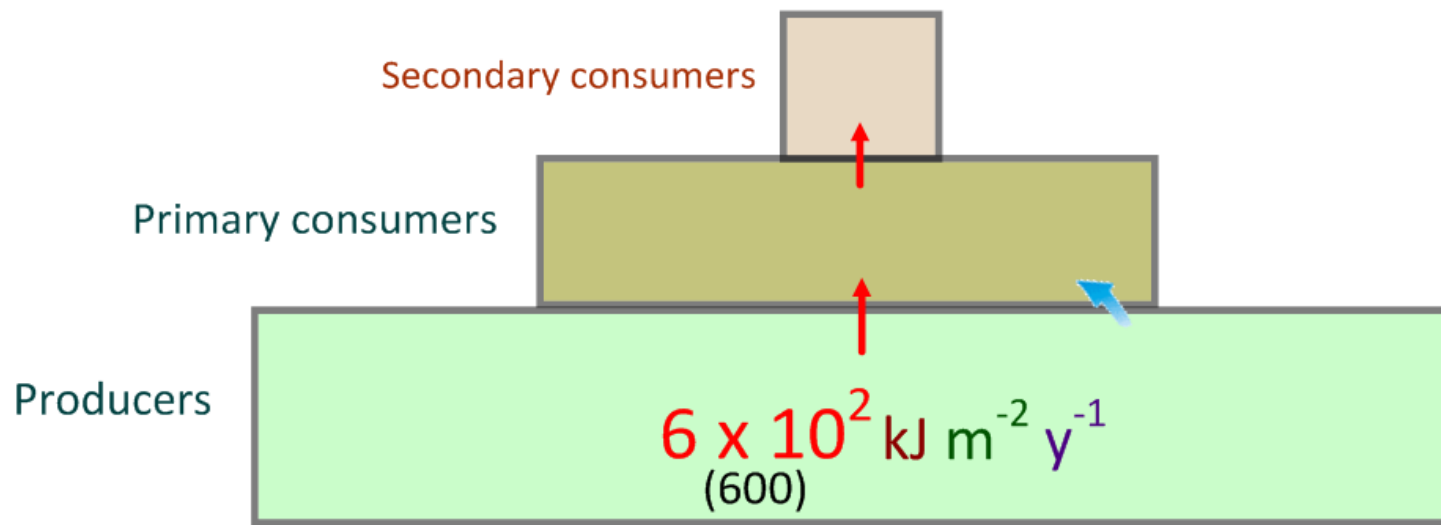
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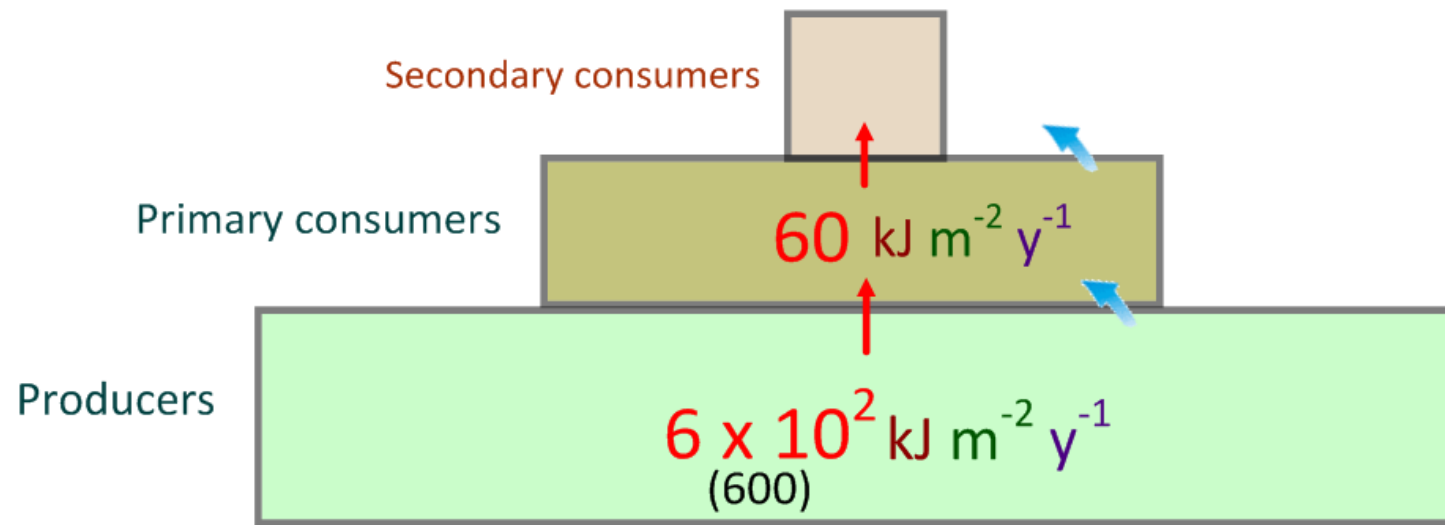
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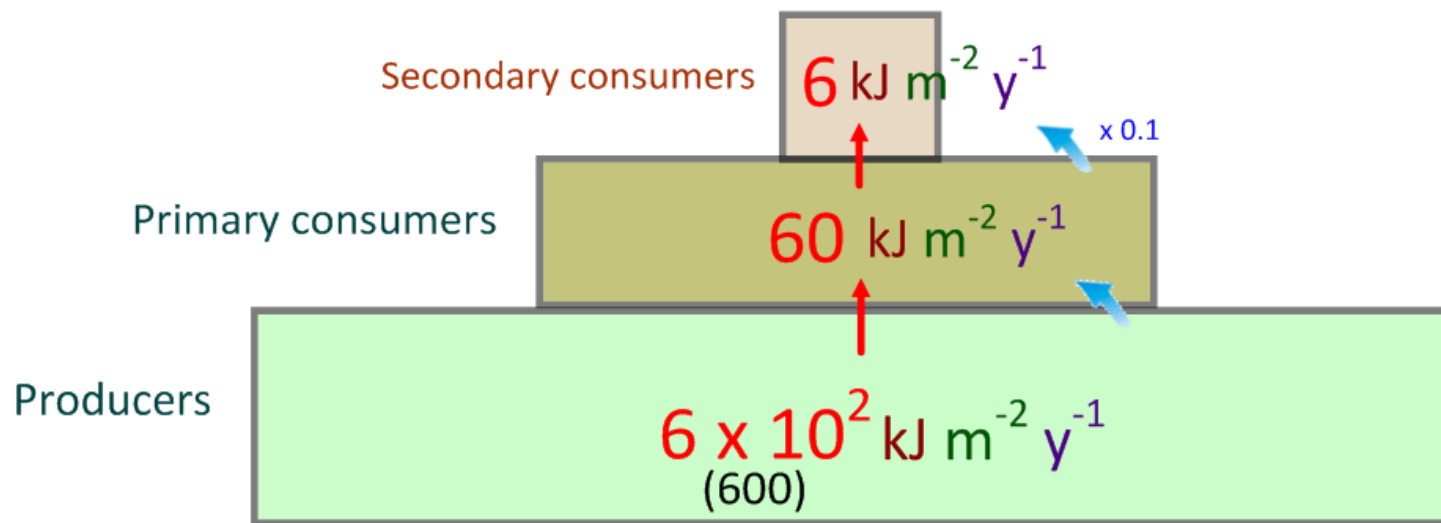
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What is the efficiency of the conversion of solar energy by photosynthesis?

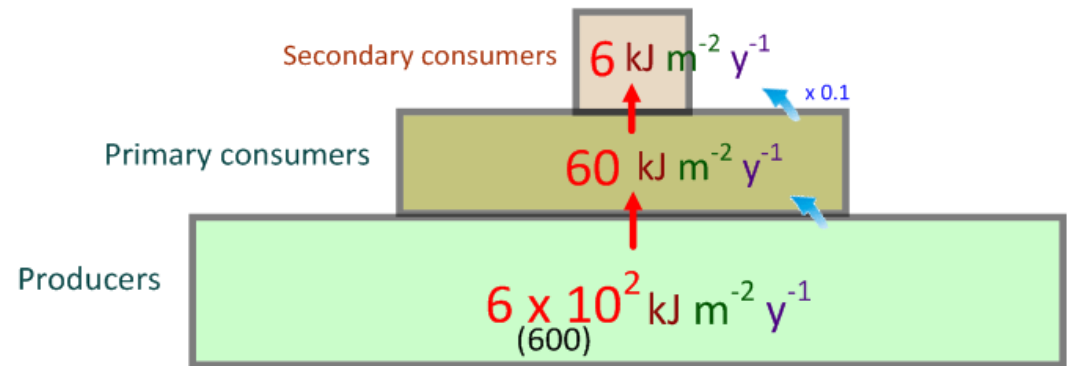
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$$\text{Efficiency} = \frac{\text{Gross production}}{\text{Energy in}} \times 100$$

$$\text{Efficiency} = \frac{6 \times 10^2 \text{ kJ m}^{-2} \text{ y}^{-1}}{5 \times 10^5 \text{ kJ m}^{-2} \text{ y}^{-1}} \times 100 = 0.12\%$$

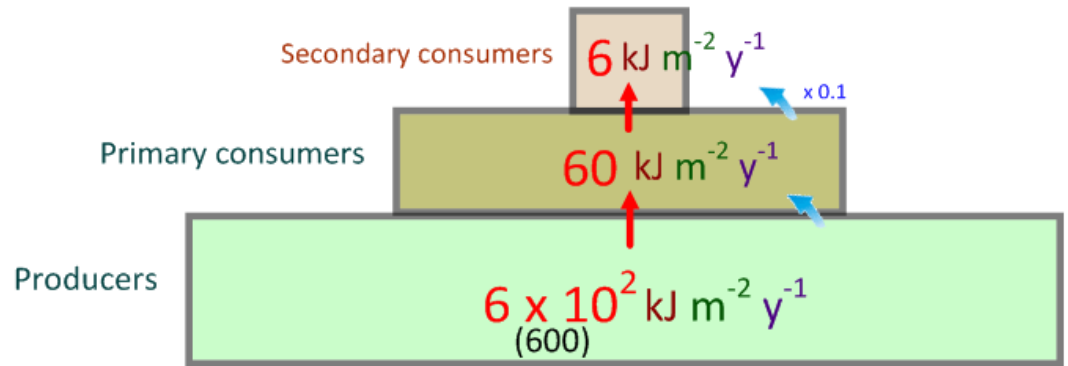
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$$NP = GP - R \quad \therefore$$

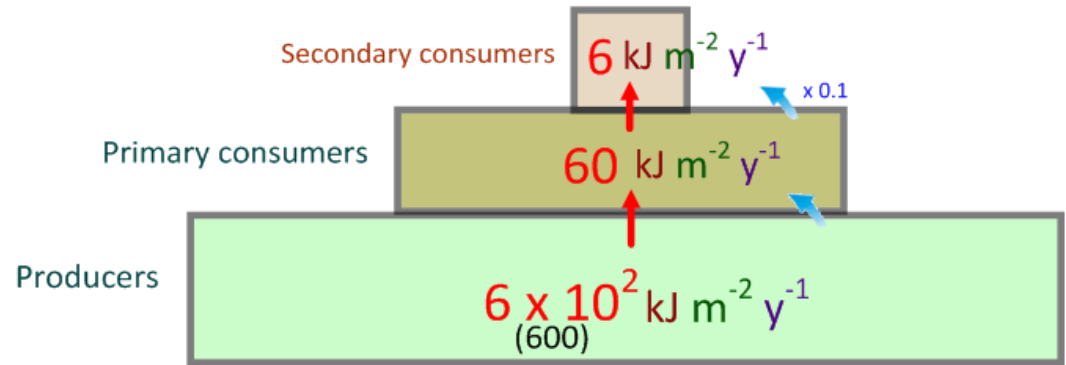
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$$\text{NP} = \text{GP} - \text{R} \quad \therefore \quad \text{R} = \text{GP} - \text{NP}$$

$$= 6 \times 10^2 \text{ kJ m}^{-2} \text{ y}^{-1} - 5 \times 10^2 \text{ kJ m}^{-2} \text{ y}^{-1}$$

$$= 1 \times 10^2 \text{ kJ m}^{-2} \text{ y}^{-1}$$

$(100 \text{ kJ m}^{-2} \text{ y}^{-1})$

Biomass - what does it tell us?

*Biomass is the **total dry mass** of **organic matter** in **organisms** or **ecosystems**.*

By measuring the **biomass** of an ecosystem, we can see how **productive** it is - and compare this to other ecosystems or past data.

This might be used as a **measure of the 'health' of an ecosystem** - a significant decline in productivity would be a cause for concern.

Farmers may measure biomass as a method of assessing growth strategies.

Environmental or town protection agencies may use biomass data to assess the usefulness (or potential risk in a wildfire) of an area of vegetation.

1. Collect samples and estimate numbers of all species (including animals) in the ecosystem.

2. Sort into trophic levels.

3. Dessicate



4. Measure mass of each trophic level
Check your results (dry again and re-weigh)



Think: with such a destructive method, how do researchers minimise the amount of organisms they have to kill?

How would you design a collection method that would give reliable data with minimal destruction?

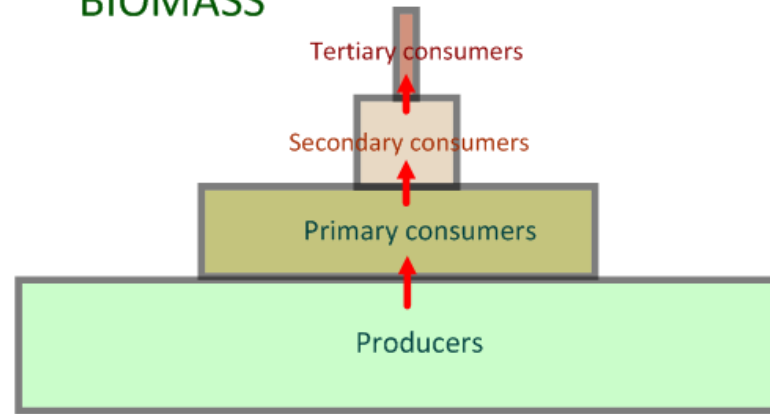
Why are **biomass** and **numbers** small at higher trophic levels?

Around 90% of energy is lost between trophic levels:

- not ingested (eaten)
- not digested or assimilated
- excreted
- lost as heat from respiration

This energy is not available for conversion into biomass.

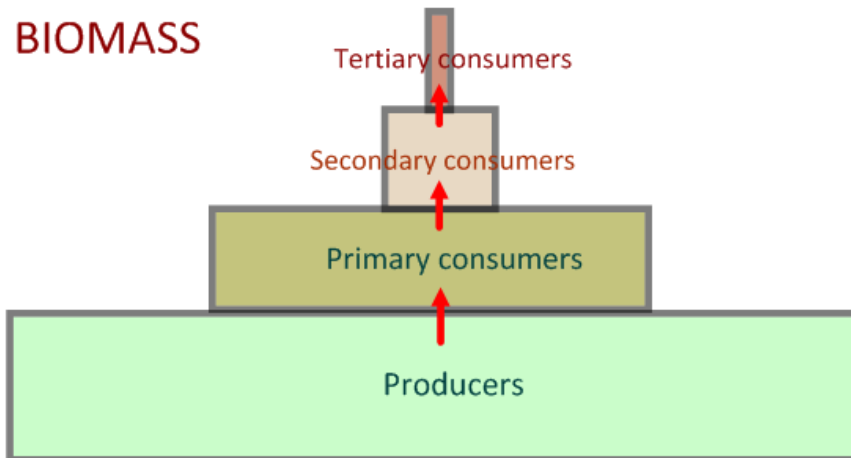
BIOMASS



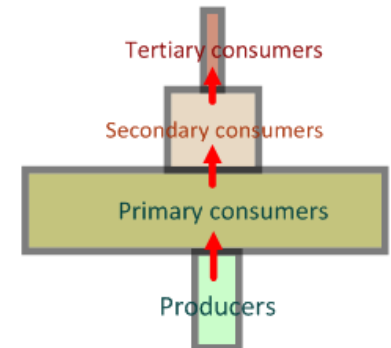
Carbon, in the form of CO_2 , is also lost through respiration and unavailable for conversion to organic matter.

As so much **energy is lost** between trophic levels, **less food is available** to organisms further along the food chain - **consumers need to eat many of their prey** in order to survive. This gives lower numbers in higher trophic levels.

BIOMASS



This pyramid of numbers represents a community supported by one large producer, such as a tree



Many species **cannot be classified** as belonging solely to **one trophic level**.

Many animals (including chimps and humans) **feed on both producers and consumers** - putting us in the levels of primary and secondary consumer.

Some are even primary, secondary and tertiary consumers, including herring.



Some **unicellular organisms** ingest other organisms (by **phagocytosis**), yet also contain **chloroplasts** for photosynthesis. *Euglena* is an example.

Many fungi are classified as detritivores or saprotrophs, yet feed on organisms that are still alive.

Think about athlete's foot!



yummy

Most often, we would classify the organism by its most common food source - how might these classifications change if some food sources were endangered or wiped out?

The reef food web is very complex:



http://www.coralreef.noaa.gov/images/iyor_foodweb.jpg

Ecological Succession

the **predictable** and **orderly** changes in **composition** of an **ecosystem** over time.

Primary succession

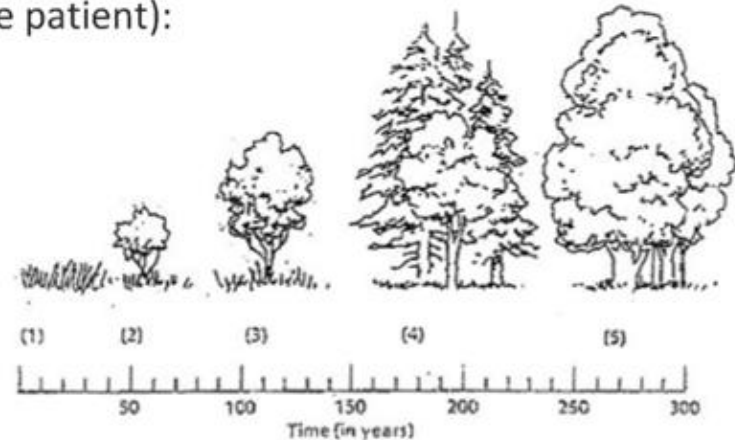
A new volcanic island forms in Tonga:



<http://news.softpedia.com/news/New-Volcanic-Island-in-Tonga-Cedes-By-The-Waves-41114.shtml>

Secondary succession

A woodland can grow from an area of cleared grassland (just be patient):



<http://www.biologycorner.com/worksheets/succession.html>

Primary:

the emergence of an entirely new ecosystem, such as a volcanic island.

Secondary:

the replacement of one ecosystem by another following environmental change

Primary vs Secondary Succession animation:



primary succession

Pause Animation

secondary succession



Reset Animation

Two types of ecological succession. Click the buttons for an example of each.

http://geoclio.org/ensci/imagesbook/04_03_succession.swf

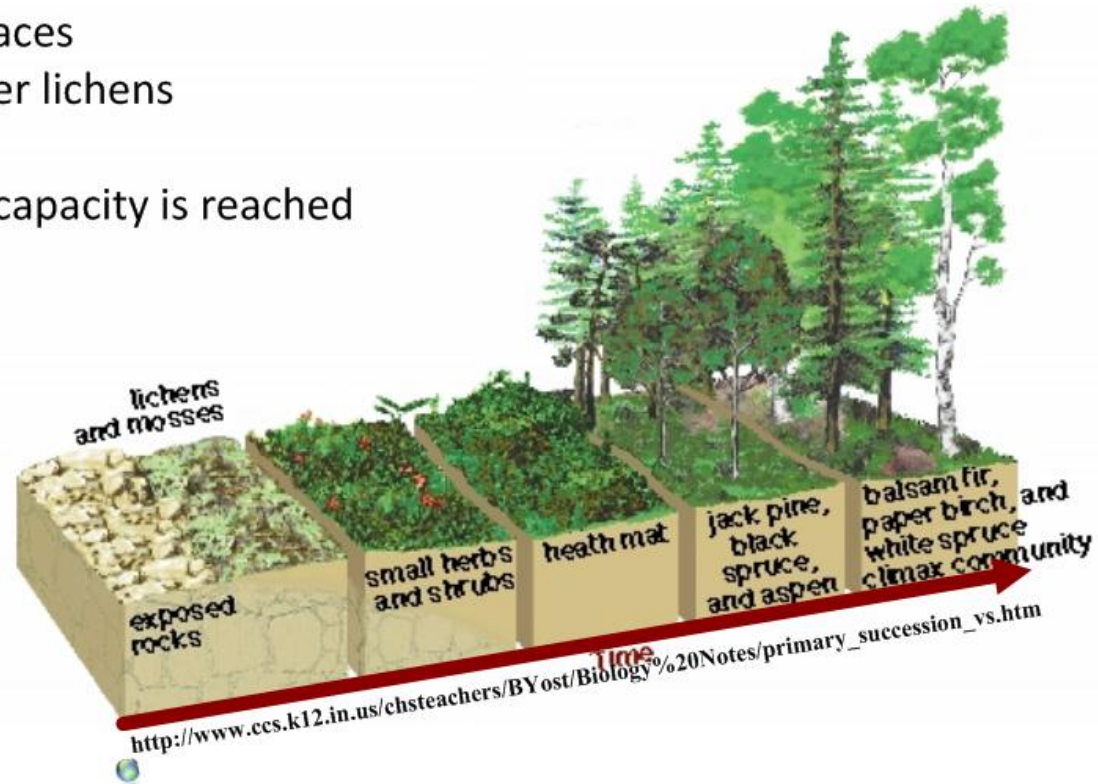
Primary Succession is the emergence of a new community from a new ecosystem.

Gross production increases

- first colonisers are lichens on rock surfaces
- soil builds up, following death of smaller lichens
- larger plants take root as soil deepens
- productivity plateaus as soil's carrying capacity is reached

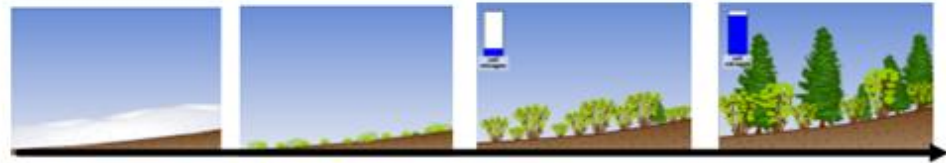
Species diversity increases

- more soils allows for burrowers, worms and detritivores
- more plants take root and provide new niches
- more death leads to more soil and nutrient recycling



0-5 years

150 years +



View this tutorial at:

<http://bcs.whfreeman.com/thelifewire/content/chp55/55020.html>

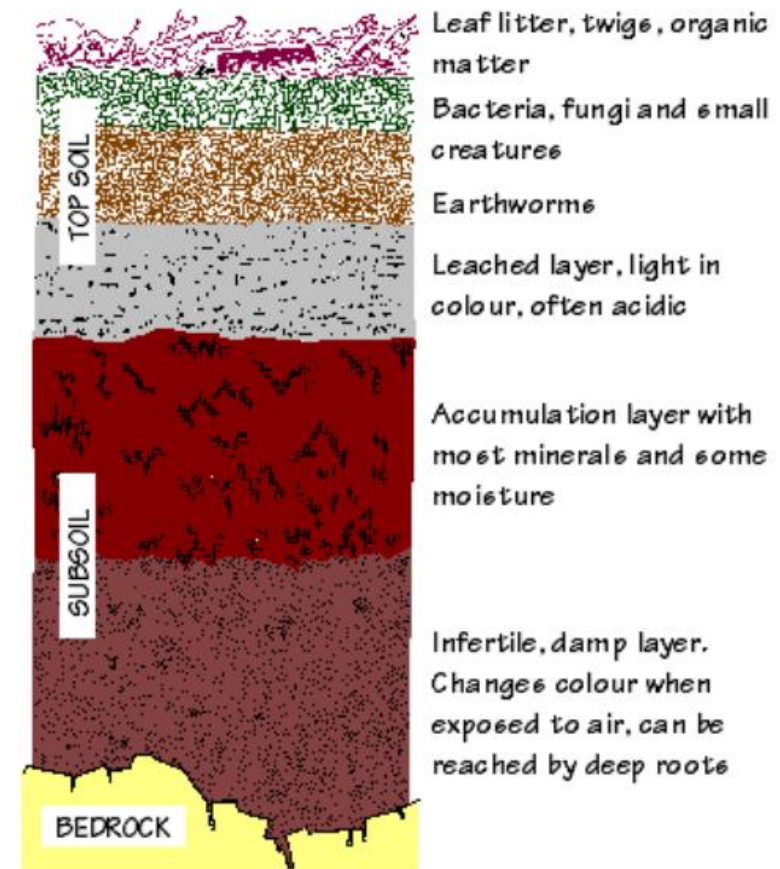
During succession, living organisms change the abiotic environment

Soil:

- Produced by **detritivores (worms)** following death of other plants and animals
- Detritivores and bacteria **fix nitrogen and other inorganic nutrients** into the soil
- Decay **accumulates minerals** around roots
- **Aerated by burrowing animals:** more respiration and drainage

Plant roots:

- **Bind the soil, preventing erosion,**
- Support large plants
- Uptake, filter and recycle massive amounts of **water,** preventing flood and drought



<http://www.self-willed-land.org.uk/permaculture/soil.gif>

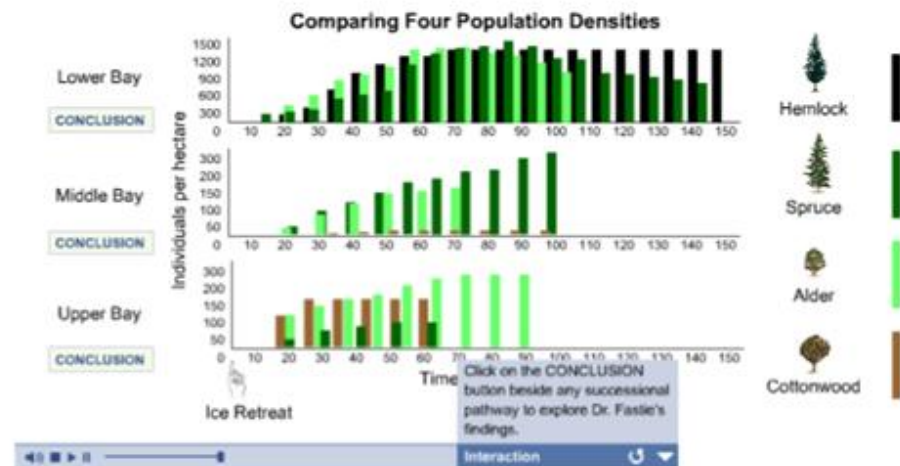


Microclimates are generated - small niches of differing temperature, light levels and humidity. These new niches provide opportunities for more species, in turn affecting the abiotic environment.

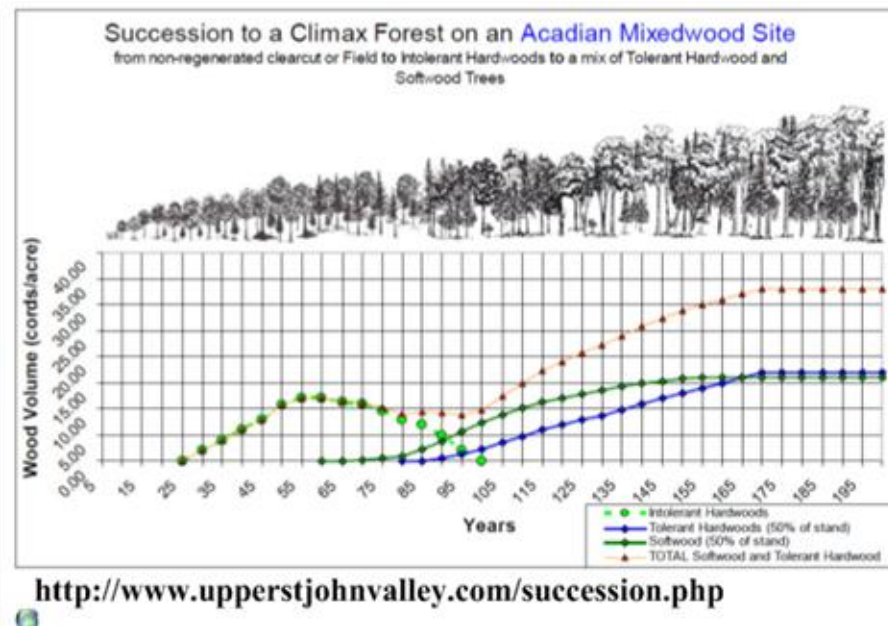
Data analysis practice:

Using these data-based resources, create questions that fit the format of the IB Biology Structured Data Analysis questions. Swap them with another group and answer each other's. Visit the source sites to make sure you are correct.

Succession on a glacial moraine

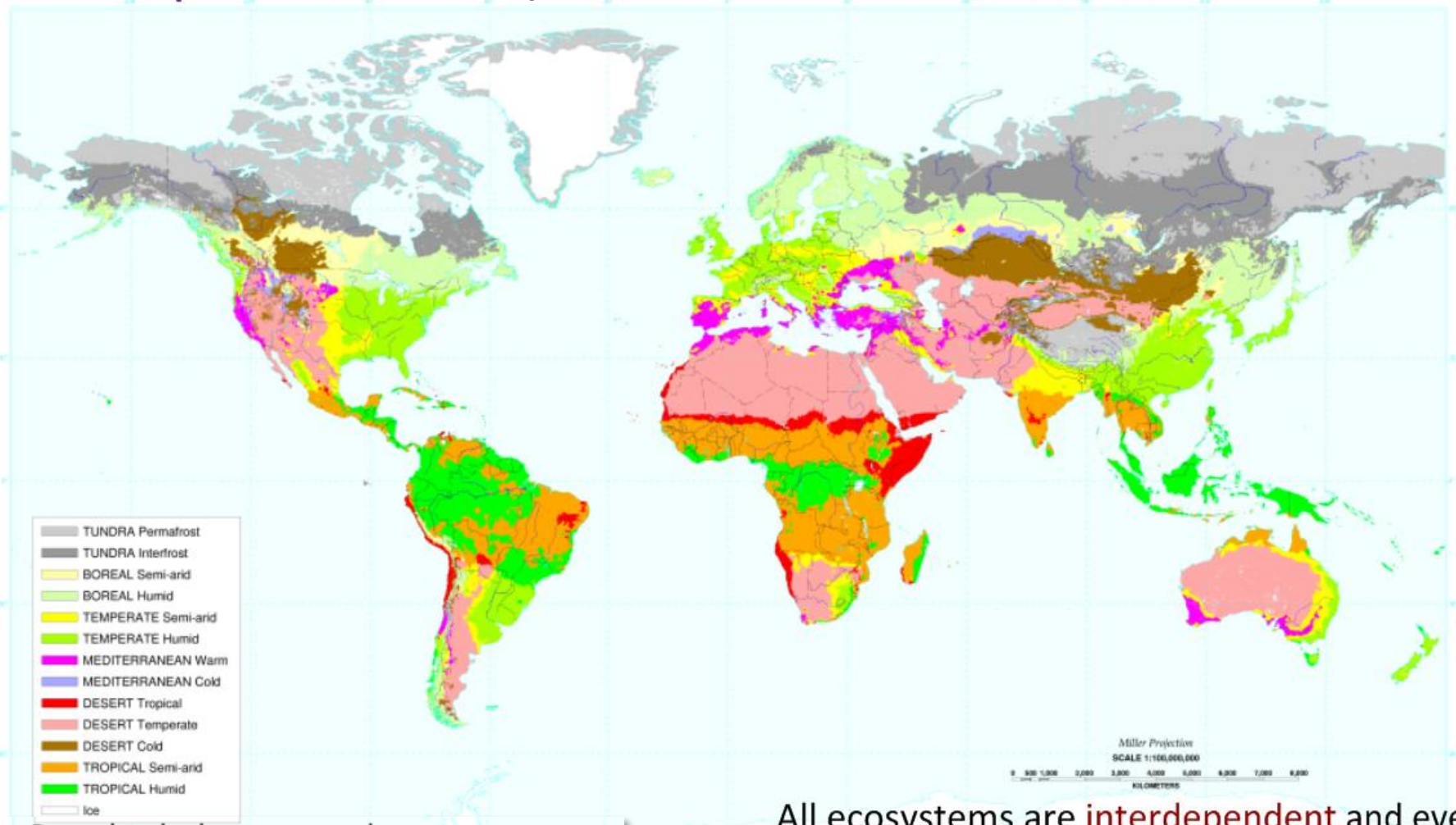


http://www.nodvin.net/snhu/SCI219/demos/Chapter_4/Chapter_04/Present/animations/50_2_4_2.html



<http://www.upperstjohnvalley.com/succession.php>

The **Biosphere** is made up of all of the world's **biomes**.



Download a huge poster here:
<http://soils.usda.gov/use/worldsoils/mapindex/biomes.html>

All ecosystems are **interdependent** and events in one ecosystem affect those in another.

Find biome data here:



Earth Observatory

[Home](#) [Image of the Day](#) [Feature Articles](#) [News](#) [Natural Hazards](#) [Global Maps](#) [Blogs](#)

<http://earthobservatory.nasa.gov/Experiments/Biome/graphindex.php>

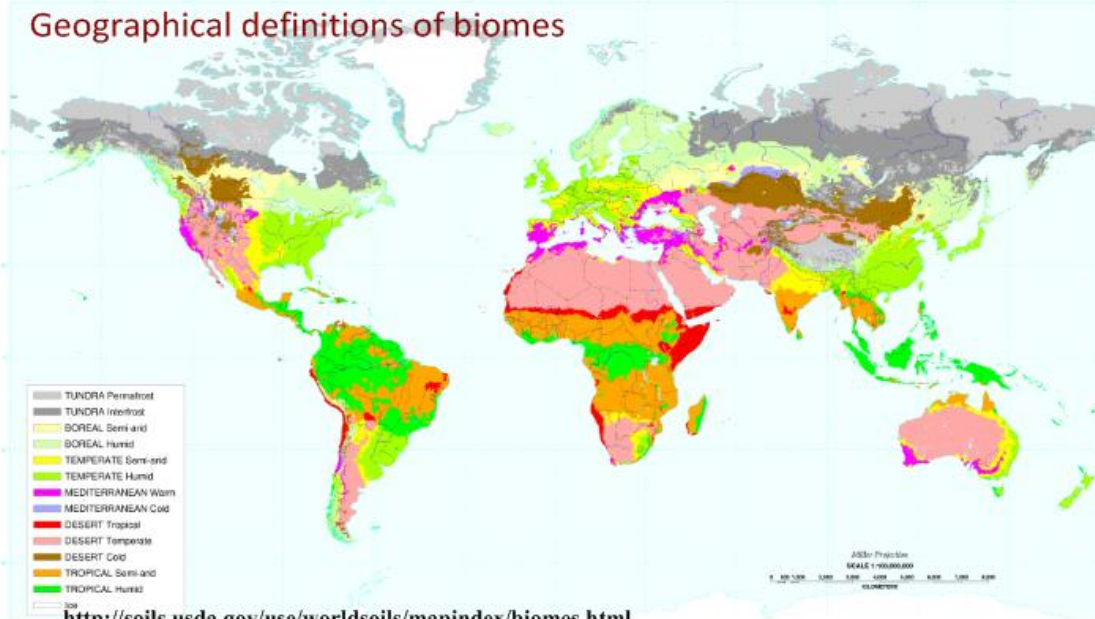
Biomes are simply components of a larger, unified ecological system - the **biosphere**.

Biomes

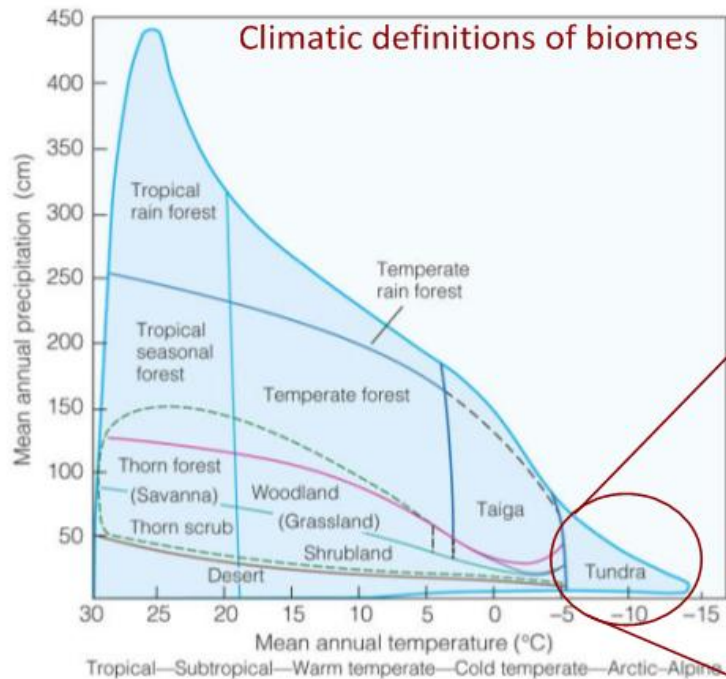
Climatically and geographically defined areas of ecologically similar characteristics.

Temperature and rainfall are key abiotic features of each biome and plant and animal species are adapted to survive in the available niches.

Geographical definitions of biomes

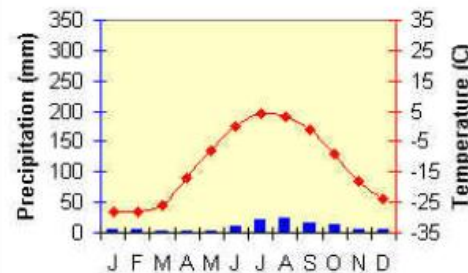


Climatic definitions of biomes



This temperature vs precipitation (snow, hail and rain) **climograph** shows how closely related neighbouring biomes are in terms of their climate characteristics.

Barrow, Alaska



An individual **climograph** can be produced for each biome (or any location), showing precipitation and temperature throughout the year.

All climographs taken from:
http://www.uwsp.edu/geo/faculty/ritter/geog101/textbook/climate_systems/outline.html

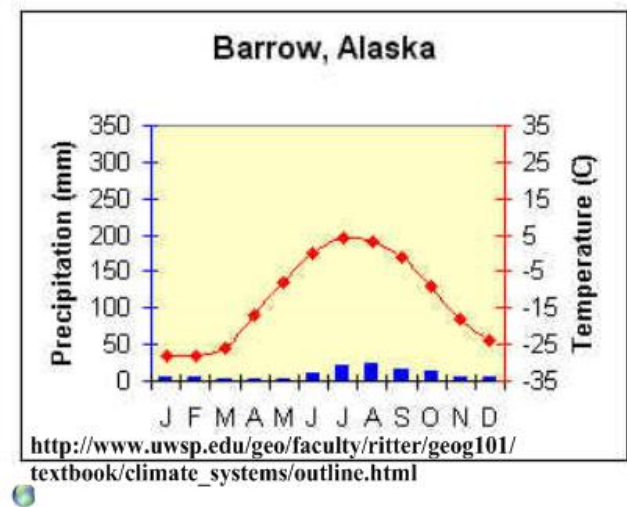
Tundra

The "tree-less" plains & alpine regions.

Low annual temperatures (mostly below freezing) and low precipitation.

Plant species are adapted to high exposure and harsh conditions and photosynthesise in low light:

- short shrubs and bushes
- tough grasses, mosses and lichens



The Tundra - a dangerous place to be



<http://www.youtube.com/watch?v=9IjGNJPYzU&feature=fvst>

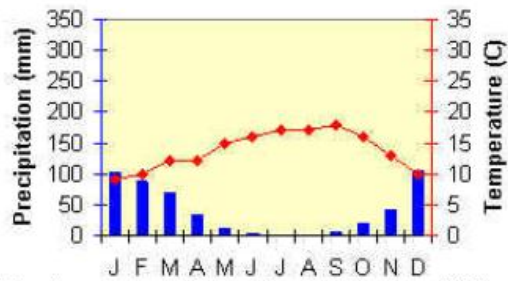
Image: 'Free Air'
www.flickr.com/photos/33657660@N00/69743110



Image: 'The Flattest Flat'
www.flickr.com/photos/20697369@N00/252071908



San Francisco, CA



http://www.uwsp.edu/geo/faculty/ritter/geog101/textbook/climate_systems/outline.html

Image: 'Huge Column'

www.flickr.com/photos/40776356@N00/265950997

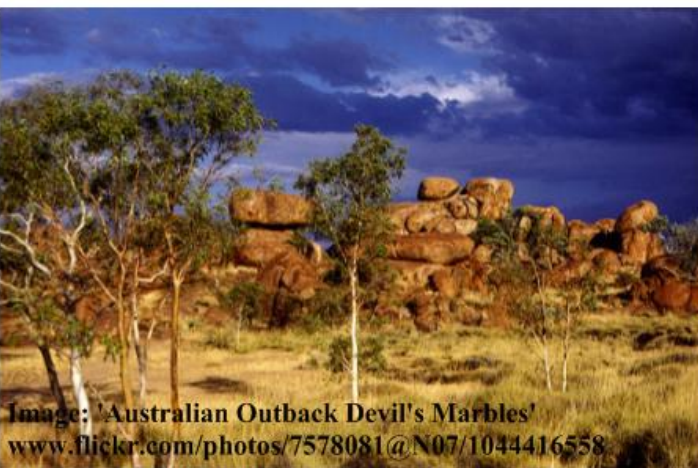
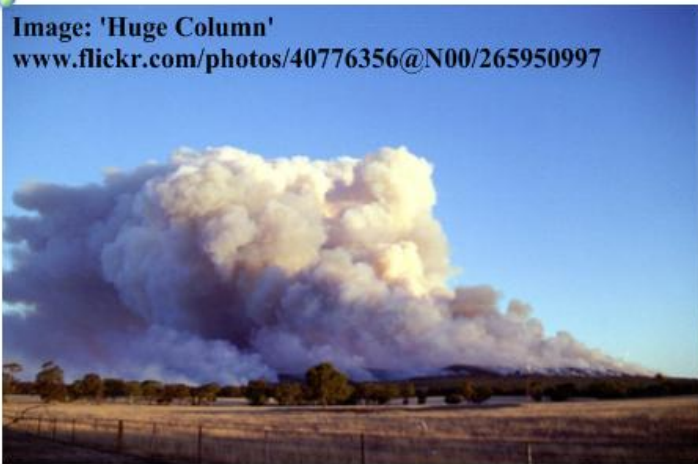


Image: 'Australian Outback Devil's Marbles'

www.flickr.com/photos/7578081@N07/1044416558

Shrubland

Warm-hot summers and cool winters.

Dry summers and wet winters.

Natural fires are common in the summer, such as in the Australian bush, California and parts of the Mediterranean.

Vegetation is adapted to dry conditions (xerophytes) and some seeds are stimulated to germinate by fire.

Seasonal change in foliage is rare - they stay green all year round.

Australian bushfires 2009:



<http://www.youtube.com/watch?v=NajOATpglqc>

Grassland

Large annual range in temperature and precipitation.

Warm-hot summers and cold winters.

Heavy rain in summer-autumn.

High diversity of grasses, shrubs and some trees. Lots of grazers present.

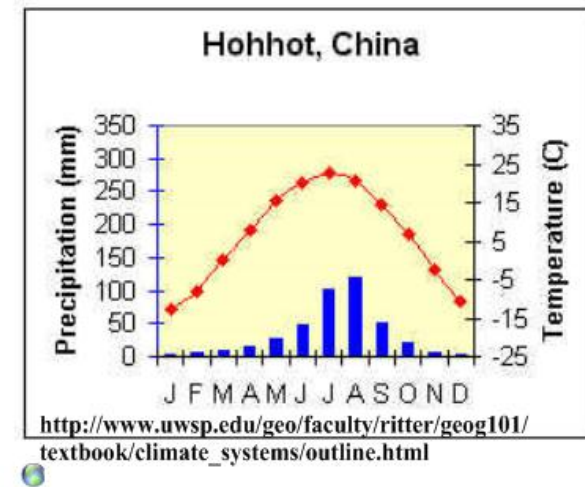
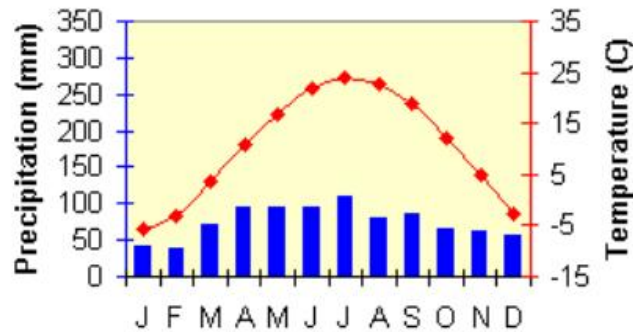


Image: 'Kuerdening Valley'
www.flickr.com/photos/59328895@N00/489868429



Image: 'Rainbow, Tuscany, Italy'
www.flickr.com/photos/13010608@N02/2440884617

Peoria, Illinois
40.7 N; 89.7 W



http://www.uwsp.edu/geo/faculty/ritter/geog101/textbook/climate_systems/outline.html

Temperate Deciduous Forest

Clear seasonal changes with warm summers, cold winters and rainfall all year round.

Deciduous foliage in leaf during spring and summer and leaves fall off in the autumn and winter.

Broadleaf trees (oaks, maples, beeches), shrubs, perennial herbs, and mosses.

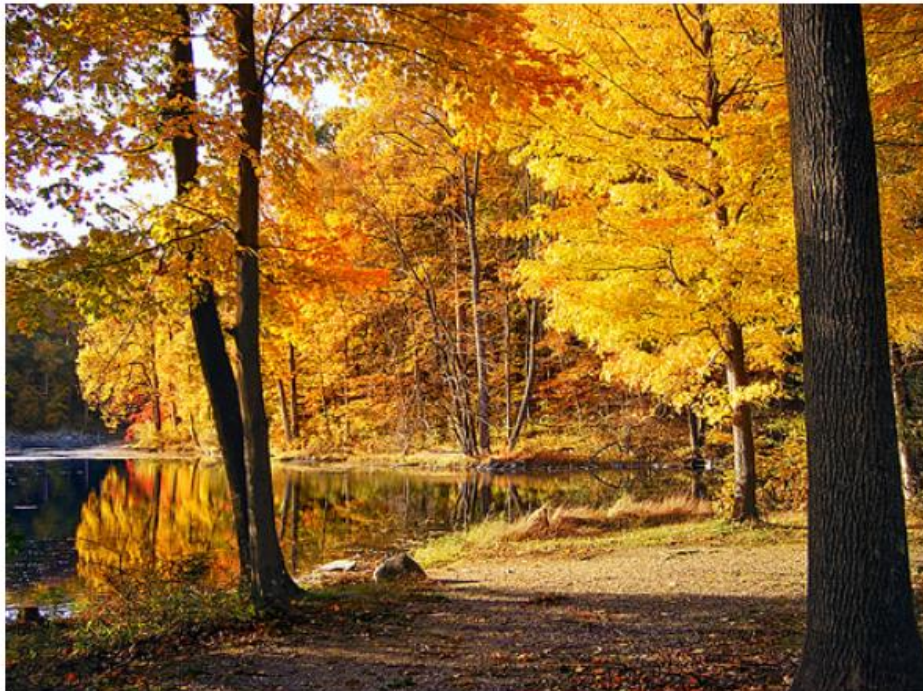


Image: 'Ablaze'
www.flickr.com/photos/14922165@N00/270891582



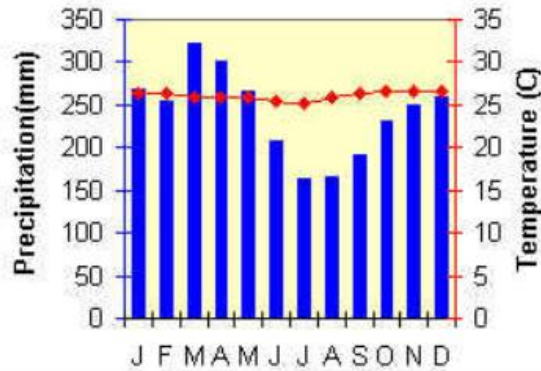
Image: 'Memories of Green'
www.flickr.com/photos/14922165@N00/404916872

Tropical Rainforest

High annual temperatures with little fluctuation.
High annual rainfall with 'wet' and 'dry' (not so wet) seasons.

High diversity of plant and animal life due to high number of ecological niches available. Tall trees, vines, mosses and other plants. Rainforests are divided into vertical layers: the forest floor, the lower canopy, upper canopy and emergent top trees.

Iquitos, Peru



http://www.uwsp.edu/geo/faculty/ritter/geog101/textbook/climate_systems/outline.html



Image: 'cloud forest, Sandakan'
www.flickr.com/photos/58117789@N00/76591953

Some amazing Borneo species:

Crazy Looking Creatures - Expedition Borneo - BBC wildlife

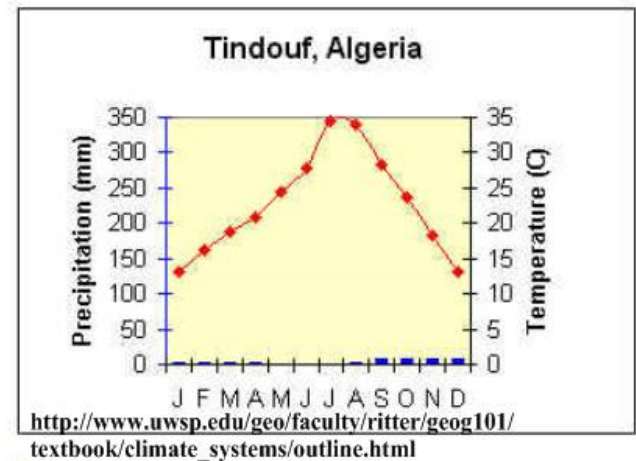


<http://www.youtube.com/watch?v=Dq1uYknD-d0>

Desert

Hot and dry all year round, with cold nights.
Very low precipitation.

Plant species are extreme xerophytes and plant and animal diversity are low. Cacti, short bushes, some short grasses.

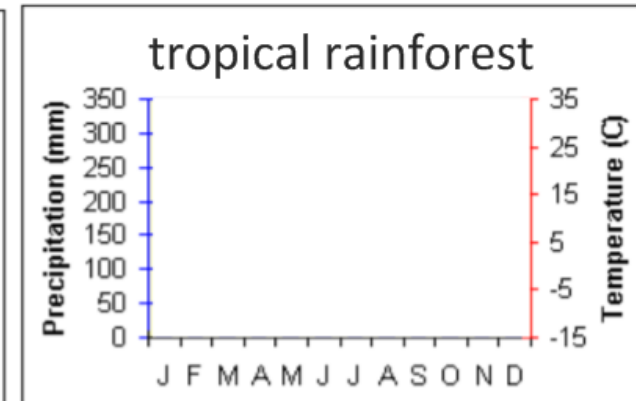
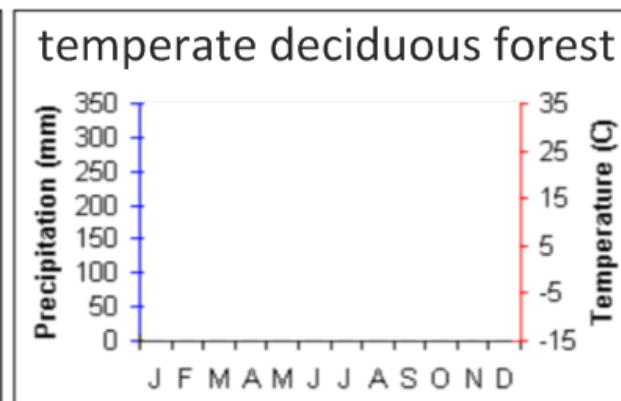
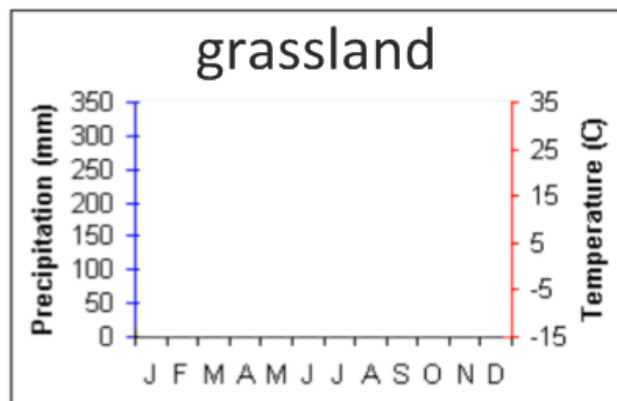
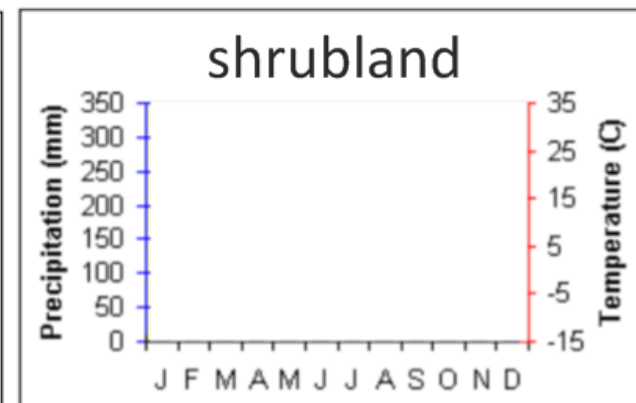
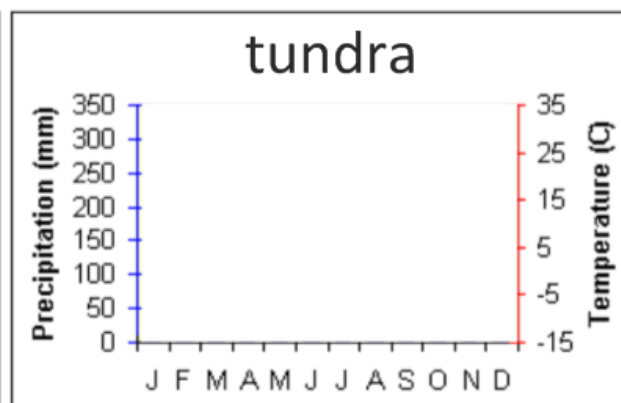
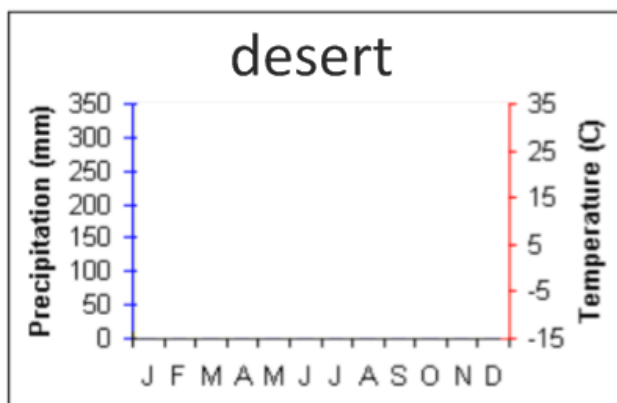


HL Plant Science:

What are some of the physical, metabolic and life-cycle adaptations found in extreme xerophyte plant species?



Test yourself: Print this page and draw the climographs



For biome information (and climographs) visit:



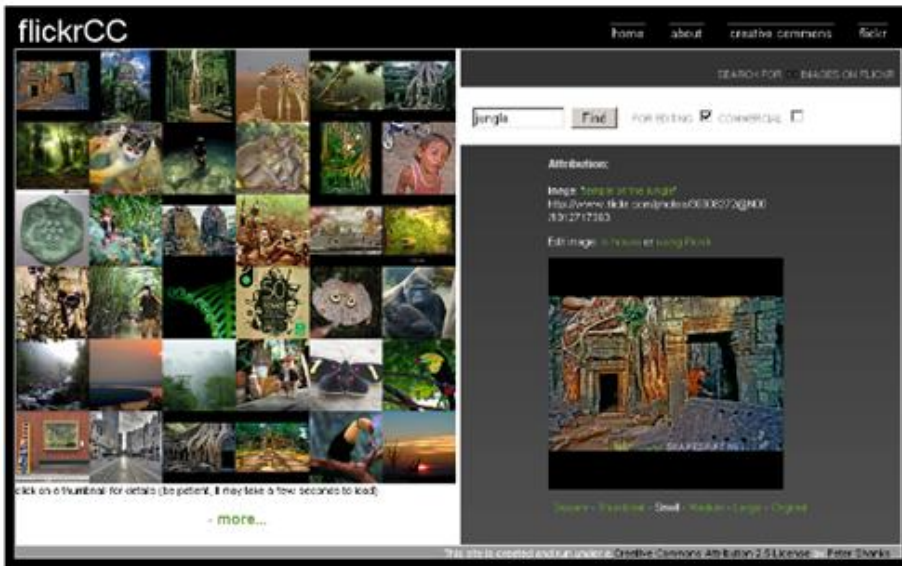
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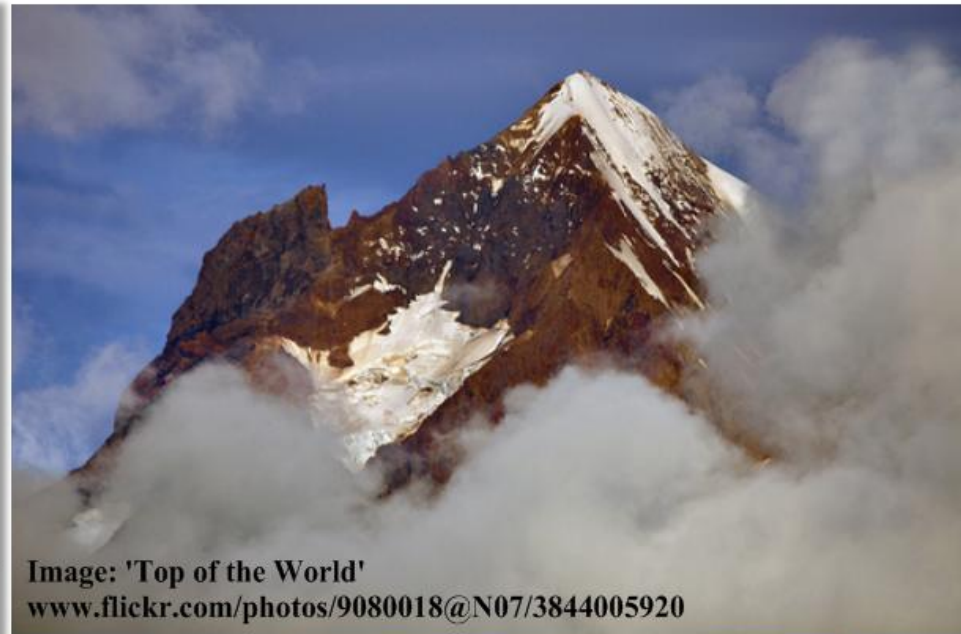


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